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# The Role of Housing in a Mixed-Asset Portfolio: The Particular Case of Direct Housing within the Greater Paris Region

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## Abstract

Given the importance of the residential property sector, we propose to study direct housing as an asset class within the optimal multi-asset portfolio. In this study, we consider the performances of direct housing within the metropolis Grand Paris between 1996 and 2017. We test the inflation hedging property of direct housing as well as its diversification benefits. We also define the optimal weight of this particular asset class when held together with stocks and bonds. Our finds bring several contributions to the French residential market within a portfolio management context. First, directly-held housing investment should bring diversification benefits to the mixed-asset portfolio. Second, residential asset is confirmed to be a hedge against inflation and particularly against its unexpected component. Third, using hierarchical clustering technique, we divided the “Grand Paris” into five homogenous groups of communes and give the optimal weight of each of the 150 communes and each group of communes into the tangency portfolio. Weights stability through time is checked through moving windows. We also compare our finding when considering listed real estate with direct housings.

*Key words: Direct housing, “Grand Paris” metropolis, inflation hedge, diversification, Sharpe maximizing portfolio allocation.*

## **1. Motivation**

The role of real estate as an asset class has been extensively discussed in the theoretical and empirical literature. Distinction should be made first between direct and indirect real estate, and second between the various asset classes within the real estate asset itself. As the real estate market is not homogeneous, drivers are specific to each asset market causing thus out or under performance of some asset classes compared to others.

In this study we focus on the direct housing investment in the communes of the Greater Paris region, and we empirically investigate its role within a mixed asset portfolio initially composed of stock, bond and cash.

Direct housing has always been considered as the most important property investment for households in France. However, the dual nature of housing makes the demand for it not only driven by consumption purposes but also by investment purposes. That is moreover why housing account for a significant share of the total wealth of households, either as home owner-occupiers or rental investors. According to INSEE<sup>1</sup> figures between 1998 and 2015, the share of population holding securities, such as stocks and bonds, declined from 21.2% to 16.5%, while the population holding property portfolios grew from 58.5% to 62.7%. In 2015, 58.9% of the total population own their principal residence and 18% own other housing units.

Along with private individual investments, there is a growing renewed interest in housing asset from institutional investors; in recent years, the spread between the yield on commercial real estate and housing has never been that tight.

Therefore, from an investor standpoint the direct housing as an investment vehicle should be considered as part of mixed-asset portfolios. In fact, and in accordance with our results, substantial weighting is allocated to direct housing in mixed-asset portfolios. This is not a mere coincidence since the residential asset presents key characteristics that strengthen its role as a long-term worthwhile investment, at least within the mean-variance efficiency framework. As a matter of fact, the residential asset tends to be less volatile than other investments and generates steady cash flows. The risk level of the expected cash flows produced by residential property is partly shaped by the degree of uncertainty about future relative supply and demand for property space.

Furthermore, Paris is experiencing a particularly opportune moment; 100 years after its last Games in 1924, Paris is awarded for the third time the Olympic and Paralympic Games in 2024. This represents a tremendous opportunity for Paris and its surroundings to confirm and to increase their attractiveness in a number of areas. The successful Parisian bid is a particularly good news as the Games would fit right into the Greater Paris project: the regional development plan for *Île-de-France*. The latter covers several fields, the one that interests us is the transportation network and its impacts on the housing market.

Actually, the Parisian region is already endowed with a dense and well-developed public transport network. However, when it comes to meet an increased need (although transient during the Games in 2024), it becomes necessary to densify and to expand the existing transport network on the scale of the metropolitan area of Paris. The underway project of Grand Paris Express is an important step towards achieving this goal.

In this study, we use the Modern Portfolio Theory (Markowitz, 1952) to analyze the direct housing performance and allocation. This framework suggests that investors rely not only on the risk-return profiles of asset classes, but also on the interaction between asset classes which is central to their allocation decisions. The correlation analysis conducted indicates that directly-held private housing investment should bring diversification benefits to the mixed-asset portfolio since it exhibits low and non-significant correlations with stocks and bonds. In addition, our study shows that the efficient frontiers that include direct housing together with other assets dominate the one that includes only stocks, bonds and cash.

Finally, inflation-hedging properties are usually attributed to residential real estate assets. Our results confirm the positive relationship between residential returns and the Consumer Price Index.

The study is organized as follow: the next section reviews the relevant literature related to the main roles of housing within mixed asset portfolio. Section 3 presents the data. Section 4 reports the statistical analysis. Portfolio optimization is discussed in section 5. Robustness checks are conducted in section 6. Section 7 concludes.

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<sup>1</sup> « *Institut National de la Statistique et des Etudes Economiques* » which is the French national institute for statistical and economic studies.

## 2. Review of literature

### 2.1. Housing as a portfolio valuable diversifier

The direct real estate and particularly housing asset is commonly considered as a good candidate for diversification within a multi-asset portfolio. It is actually said that when added to a stock and bond portfolio, it is able to generate improved risk-adjusted returns. That is in fact one of the reasons that housing has always been part of institutional portfolios, with varying levels according to countries. One of the earliest studies that proved the usefulness of real estate as a portfolio diversifier was made by Ibbotson and Siegel (1984). They compared US real estate returns (commercial, farm and residential) to those of stocks, bonds, short-term bills and inflation over the period 1947 – 1982. They reported that the housing total return level was between those of shares and bonds. Moreover, it does not correlate significantly with them. Hartzell et al. (1986) offered a more global view of the diversification benefit of US real estate investment in a portfolio context from 1973 to 1983. They compared performances of assets returns according to various criteria such as geographic location, property type, property size, etc. They found that all property types offer higher returns than financial assets, while being less volatile. It is important to note that they used appraisal indices instead of transaction-based indices, which probably results in smoothed series. They also found that all property types including residential can offer considerable diversification benefits given the low correlation with financial assets. Liang et al. (1996), over the sample period 1982 – 1993, proxied housing asset performance by inferring value of direct housing investment from securitized apartment real estate (REITs). According to their results, only efficient portfolio of highly risk averse investors involves substantial allocation in housing. A more recent study of Wu and Pandey (2012) confirms earlier findings in the US. The authors found that adding residential asset can enhance portfolio efficiency. Further evidence came from other countries. The results are generally similar to those recorded with U.S. market data. For instance, Hoesli et al. (2004) reported international evidence on real estate including residential as a portfolio diversifier. They used annual data of various financial and real estate asset classes in Australia, France, Netherlands, Sweden, Switzerland, United States and United Kingdom, for the period 1986 – 2001. They reviewed correlations between different asset classes finding that housing is moderately positively and negatively correlated to shares and bonds respectively. Therefore, they conclude that housing is an effective diversifier, particularly when both domestic and international real estate assets are considered.

Peat and Wright (2012) analyzed Australian financial and residential asset performances from 1988 to 2011 and constructed portfolios with and without the residential asset. They found that given the low correlation between residential returns and the others assets classes considered, the inclusion of residential in a mixed-asset portfolio leads to a significant shift of the efficient frontier to the left, meaning that it enables the construction of portfolio with lower (higher) volatility (expected return) for a given expected return (volatility).

To conclude, a vast majority of empirical studies agreed on the fact that housing within a mixed-asset portfolio improve its risk-return profile. This is mostly likely a consequence of the weak correlation that exists between housing and other assets, or even an inverse long-run relationship between stocks and real asset in general (Chaudhry, Myer and Webb, 1999). Hence, housing is given a significant positive weight in the optimal portfolio (for a detailed presentation of the optimal allocation across the countries, see the study of *Norges Bank*, « *The diversification potential of real estate* », 2015). In addition, one should not forget that significant diversification benefits are achievable only when the overall market is sufficiently large (Muralidhar, 2001, Montezuma and Gibb, 2006), which is the case in our area of interest, the Grand Paris area.

## 2.2. Housing as an inflation hedge asset

Along with diversification ability, the housing asset may be considered as an effective hedge against inflation. Following a long inflationary period between the post war to the mid 1980' (+10.1% annually), France went through a moderate inflation period between 1986 and 2001 (+2.1% annually), and even lower inflation between 2002 and 2016 (+1.4% annually).

Therefore, currently the threat of inflation is not topical. However, it might be back in France and in Europe more generally. This would be partly due to the monetary policies of the European Central Bank, especially the quantitative easing and the reduction of key interest rates, whose main consequence is the increase of the money supply and thus inflation.

In such context, inflation hedging should remain an important concern for investors. Particularly long-term investors, who are concerned with the protection of their wealth, seek to hold effective hedging assets. Since the 1970s, great interest is given to the housing inflation hedging ability. Methodologies to test it are various. One of the most used method is to assess the correlation between the movements of housing returns and inflation rate. For instance, Fama and Schwert (1977) examine the relationship between different asset classes' returns and the Treasury bill rates (considered as a proxy of expected inflation). They find that the US residential properties returns are strongly positively correlated to inflation in the period 1953 – 1971. In their study, returns of US residential property were calculated based on capital appraisal index.

On the contrary, authors like Fogler et al. (1985) use US housing returns based on transaction prices index (instead of appraisal index). They also report a positive relationship between those returns and inflation between 1952 and 1983. Ben-Shahar, using transaction prices indexes (the Dwelling Price Index) in 25 Israeli cities between 1990 and 2000, proves that a dwelling portfolio provides a positive hedge against actual, expected and unexpected inflation.

Ruben, Bond and Webb (1989) tested the hedging effectiveness of various asset classes over the period 1960 – 1986. They found that the residential properties were the only complete positive hedge against actual and unexpected inflation.

These results are corroborated by Moigne and Viveiros (2008). They find that direct real estate investments including residential act as a complete hedge against expected inflation and even as an “overhedge” against unexpected inflation (i.e. the coefficient associated to unexpected inflation in their regression is higher than 1).

However, some authors criticized the use of conventional statistical methods especially when the stationarity of the series is not proved (Chaudhry, Myer, and Webb, 1999). To overcome this issue, Anari and Kolari (2002) employ autoregressive distributed lag models to investigate the long run relationship between new and existing housing prices (instead of housing returns) and consumer price index excluding housing component (instead of inflation). They report evidence in favor of inflation hedge in the long run in the United States between 1968 and 2000.

To conclude, the diversity of the elements/components that need to be considered when examining the hedging effectiveness of housing against inflation makes the task somewhat arduous. Hedging ability may differ markedly due to differences in methodologies, housing return components (price, rent or total return), inflation components (actual, expected or unexpected inflation), horizons (short run or long run), etc. Despite this, strong empirical evidence exists in favor of a positive relationship between housing returns and inflation, making the residential asset an interesting asset to hold to hedge against inflation.

A study of inflation hedging ability of direct housing asset in the communes of *Île-de-France* is conducted in section 4.

## 3. Data

This section seeks to present the asset classes included in the simulated portfolios. The latter include investments in housing real estate, stocks, bonds and cash. The physical residential markets in 150 communes in Paris and the Parisian first ring suburbs are considered as potential asset classes. More precisely, investors can buy (either to occupy or to rent) collective housing in one or several communes. In order to consider this particular asset class within a multi-asset portfolio, we need to compute the total return of housing in these communes. For that purpose, two different databases are used.

The first one is provided by the chamber of Notaries in *Île-de-France*. It contains the average annual sale price for collective housing in each one of the 150 communes between 1996 and 2017. The second one is developed by CLAMEUR (*Connaître les Loyers et Analyser les marchés dans les Espaces Ruraux et Urbains*), a private observatory of the rental market in France. It provides annual rents levels in all the French cities between 2000 and 2017. Then, the data processing mostly consists in data clean-up, by excluding communes with missing data, and harmonization of observations, by aligning all the data over the period 1996 – 2017.

Concerning the rental market, as rents series start only from 2000, we thought about a methodology that allow us to have a longer time series of data. This was possible thanks to OLAP (*Observatoire des Loyers dans l'Agglomération Parisienne*), a public observatory of rental market which is specialized in Greater Paris area and provides valuable information about rents in Paris since 1991. Thus, we manage to extend the rental database to start from 1996.

We end-up with 127 communes that give the opportunity to invest in, and for which the calculation of the total return for the whole period is possible.

There is a widespread practice of considering a decomposition of real estate returns into income returns and capital appreciation returns (Graff and Cashden,1990). Based on this idea, housing asset was represented in this study by specifically constructed annual total return from 1997 to 2017. It is the sum<sup>2</sup> of capital return and rental return. In our case, the housing total returns for each of the 127 communes are computed.

Because of missing operating expenses, managing cost of housing portfolio and measures of potential vacancy rate impact on the level of renting income, we could not consider these measures in the computation of housing total returns. As we do not have enough information that allow us to discount locally the different housing returns, we considered the gross housing total return instead of applying the same constant discount rate<sup>3</sup> to all communes.

In this study, the physical residential markets in 127 communes in Paris and the Parisian first ring suburbs are considered as potential asset classes. However, the significant number of communes would make the analysis and the graphic representation laborious. Furthermore, among these 127 residential markets, some have characteristics in common, either structural or conjunctural, which makes them quite homogeneous and thus comparable from an investor standpoint.

Given these two reasons, we simplified the analysis by clustering the 127 communes into five homogenous groups using the Ascending Hierarchical Classification (A.H.C). This technic calculates dissimilarities between objects, before grouping the ones that minimize an agglomeration selected

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<sup>2</sup> In our case, the housing total return for each of the 127 communes is computed as follow:

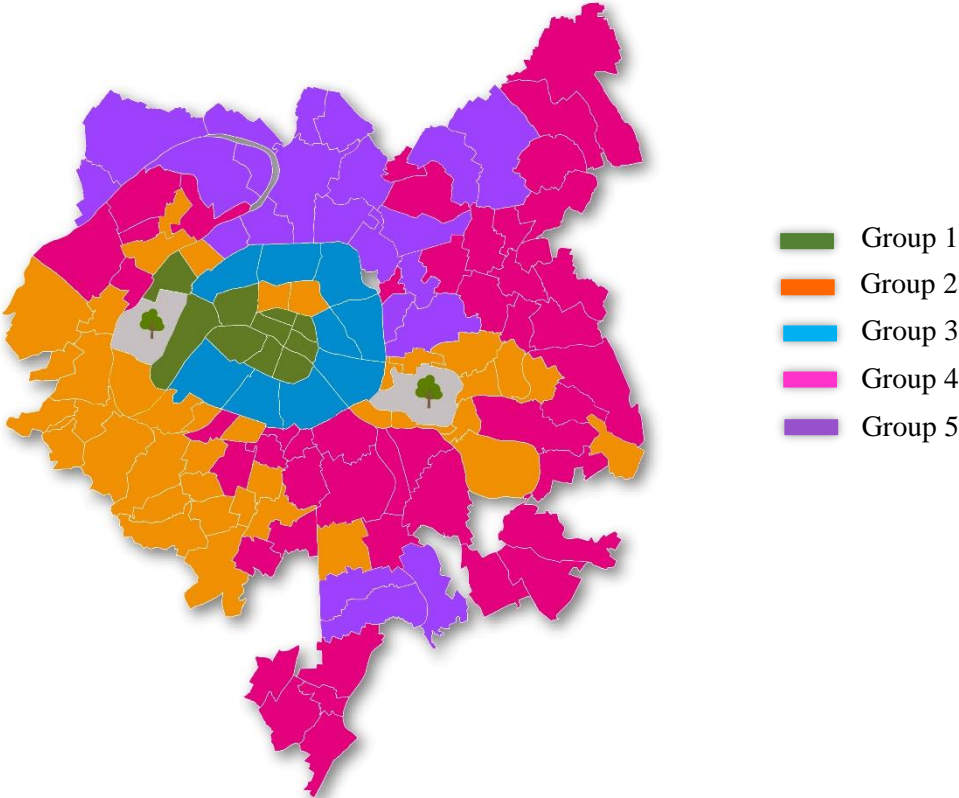
$$\begin{aligned} \text{Housing total return}_t &= \text{Rental return} + \text{capital return} \\ \Leftrightarrow HTR_t &= \frac{R_t}{P_t} + \frac{P_t - P_{t-1}}{P_t} \end{aligned}$$

Where  $R_t$  is the average level of rent per square meter in a commune during year t, and  $P_t$  and  $P_{t-1}$  are the average transaction prices per square meter in a commune during the years t and t-1.

<sup>3</sup> This is done for example in the study of Hoesli and Hamelink (1997). For operating expenses, they subtracted 150 basis points from the rental return in two swiss housing markets.

criterion and maximize the intergroup variance. This progressive grouping of a large data set produces a binary clustering tree, called dendrogram, which allow us to visualize the nodes and hierarchy of partitions, so that we can truncate the tree at the level we choose in order to get a suitable number of classes. In our case, the grouping of the numerous communes is based on 8 variables belonging three different sets: Housing market fundamentals, housing market dynamism and investors standpoint. Appendix 1 details the description of the variables used in the A.H.C. Figure 1 illustrates the five groups of communes.

**Figure 1.** The clustering of communes into five groups of communes



Group	Price	Rent	Stock	Income	Population	Return	Risk	Sharpe ratio
1	7 098 €	22,9 €	31 810	56 524 €	52 525	11,09%	7,01%	1,088
2	3 717 €	16,0 €	23 085	33 442 €	39 318	11,11%	7,08%	1,082
3	5 129 €	19,4 €	115 291	26 925 €	174 740	12,08%	7,11%	1,214
4	2 564 €	12,9 €	22 062	21 687 €	38 883	11,56%	8,50%	0,962
5	2 249 €	13,2 €	27 733	16 113 €	49 296	13,65%	9,55%	1,079

The detailed list of the communes within the five obtained groups is available in appendix 2. Table 1 gives some statistical information about the centroids of each group.

**Table 1.** The five groups centroids for the eight descriptors used in the A.H.C

In order to achieve our primary goal of portfolio optimization, we consider the investment in housing real estate together with three asset classes: stocks, bonds and cash. Besides housing total returns, we use CAC40 NR (Net Total Return) which incorporates the net reinvested dividends. The annual total

return has then two components: the dividend yield and the annual stock price evolution. Annual index from 1996 to 2017 is provided by Euronext<sup>4</sup>. Moreover, we consider the annual total return of the 10-year French government<sup>5</sup> bonds. Furthermore, we use the 3-month Euribor as a proxy of the cash asset. Yields are provided by *Macrobond*.

#### 4. Housing diversification and hedging ability

In this section, we first compare financial and housing performances. The housing asset is represented by the five groups identified above. Returns on housing groups are computed as the communes' total return weighted sum<sup>6</sup>. A correlation analysis follows. The latter enables us to state the extent to which French housing asset returns are correlated with movements in the returns of other assets, assessing therefore the validity of the key argument of considering housing as a diversifier within a mixed asset portfolio. Finally, the hedging ability of housing asset as well as other financial assets against inflation is discussed.

##### 4.1. Risk-return profiles

Table 2 reports summary statistics of total returns for stock, bond, cash and housing assets from 1997 to 2017. The period is specific because it coincides with two particular phenomenon that may cause housing prices increase: the pre papy-boom period (from 1996 to 2006) and the metropolization process which took over (with the objectives of the SDRIF<sup>7</sup> and the creation of the Grand Paris).

Thus, and in accordance with earlier findings in the empirical literature, results indicate that the housing asset in the Greater Paris area outperforms all the financial assets. The five groups exhibit the highest average returns and their standard deviations are far closer to those of bond than those of stock. This means that approximatively for the same level of risk, housing offers a much more interesting return than bond (return levels 11.9% in average vs 5.5%). On the other hand, for approximatively the same level of returns, stock is much riskier than housing (standard deviation levels 22.5% versus 7.5% in average). The risk-returns profiles of all considered assets over the sample period 1997 – 2017 are represented in figure 2. The historical Sharpe ratios ranks the housing asset far above other financial assets.

**Table 2.** Summary statistics of total returns on various asset classes, 1997 - 2017

	Stock	Bond	Cash	Group 1	Group 2	Group 3	Group 4	Group 5
Mean	0.0986	0.0553	0.0201	0.1069	0.1135	0.121	0.1168	0.1369
Standard deviation	0.2252	0.0609	0.0168	0.0679	0.0679	0.0719	0.0773	0.0845
Sharpe ratio	0.2975	0.3716	0.8001	1.2171	1.2474	1.1244	1.1386	1.2630
Median	0.1194	0.0551	0.0215	0.1211	0.1211	0.1295	0.114	0.1408
Minimum return	-0.4033	-0.0702	-0.0032	-0.0099	-0.0091	-0.0007	0.004	0.009

<sup>4</sup> We could use the annual average prices in order to be homogeneous with the housing asset class return calculation, but instead, a more common approach was preferred: closing prices were used.

<sup>5</sup> The series is initially provided by *Macrobond*, and the computation of total return series is provided by BNP Paribas Real Estate.

<sup>6</sup> We weighted each commune's total return by a size factor that indicates its weight within its group. The size factor selected is the stock in the commune, such that a total return of a group in year t is computed as follow:

$$\text{Housing group total return}_t = \sum_i^n HTR_{it} \times \frac{\text{Stock}_{it}}{\text{Stock}_t}$$

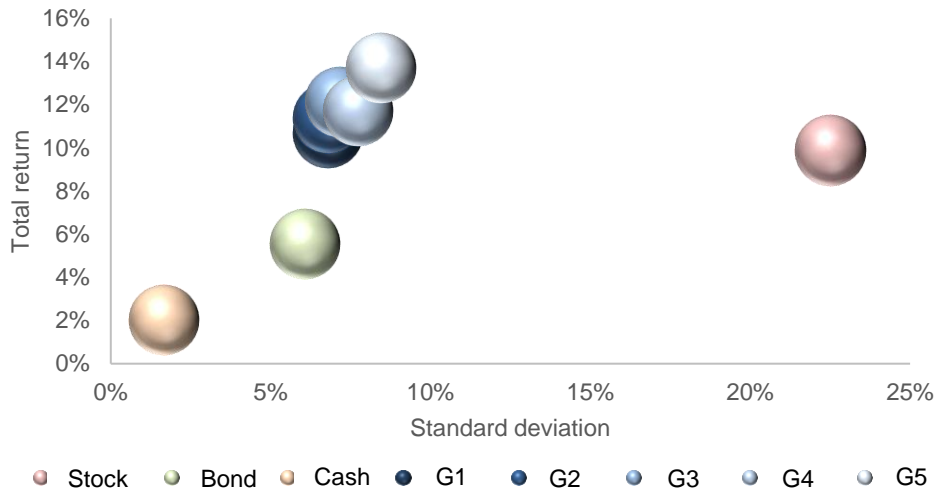
Where  $HTR_{it}$  is the housing total return in a commune i during the year t,  $\text{Stock}_{it}$  is the total number of dwellings (collective housing) in a commune i during the year t, and  $\text{Stock}_t$  is the total number of dwellings in the group of n communes.

<sup>7</sup> « Schéma Directeur de la Région d'Île-de-France »



Maximum return	0.5414	0.1624	0.0485	0.2146	0.2177	0.2191	0.2695	0.3061
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**Figure 2.** Average annual total returns and volatility measures of various asset classes

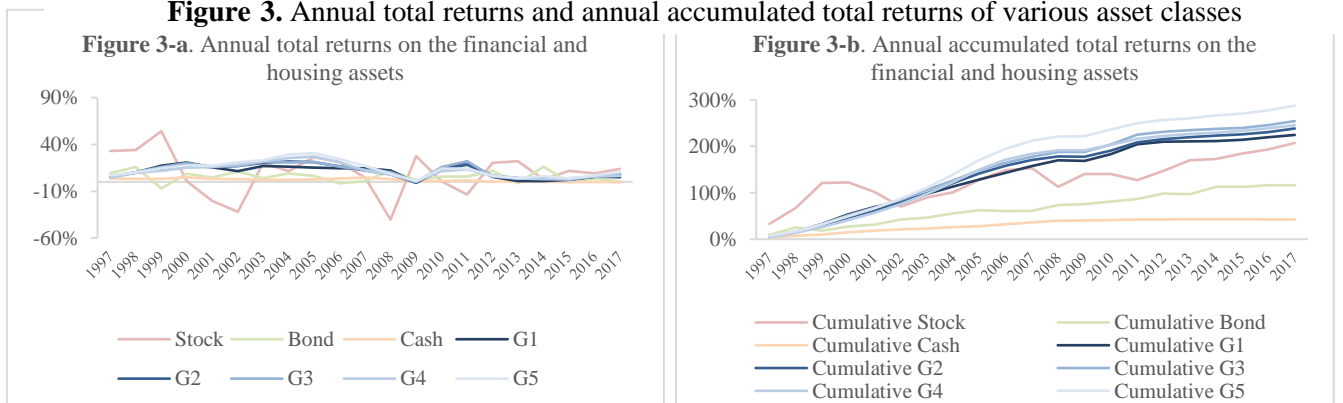


The total return series of stock, bond, cash and housing are plotted in the figure 3-a below. We can clearly see the stability of cash in contrast to the high volatility of the stock market. This indicates for example that housing returns were not always higher than stock returns and illustrates the importance of the analysis period. Over a shorter period for example from 1997 to 1999, the stock market produced better returns than did the residential property. More generally, the figure 3-b depicts the accumulated total returns of the considered assets. It shows that in term of return levels, bond and cash performed relatively poorly compared to all other assets.

The figure 3-b shows additionally that prior to the financial crisis, the stock market and residential property returns were closely competing. We can also notice that the five groups of communes are fairly homogeneous and have all experienced a stable and almost continuous positive growth over the sample period.

Among the housing assets, the fifth group has stood out since 2003. This group includes communes such as *Saint-Denis*, *Saint-Ouen*, *Montreuil*, *Villeneuve-la-Garenne*, *Ivry-sur-Seine*, etc. All these communes are gentrifying progressively. They are characterized by their proximity to the Parisian inner city, as well as their fast-changing environments. Residential prices, even though increasing year after year, are still affordable. Rents are meanwhile close to those of more expensive cities. This results in a very interesting income return in conjunction with an increasing capital gain.

**Figure 3.** Annual total returns and annual accumulated total returns of various asset classes



## 4.2. Diversification potential - Correlation of returns

From a mean-variance perspective, the housing asset seems to be very appealing as compared to financial assets. However, we still need to assess the diversification ability of housing through correlation analysis.

In table 3, we present correlations between stock, bond, cash and five housing groups total returns over the sample period 1997 – 2017. Correlations between the five groups housing returns and the stock return range from -0.21 to -0.08, while the five groups housing returns exhibit a near-zero correlation with bond (correlations range from -0.0078 to 0.01). This low-to-negative link observed between the housing returns and stock and bond is broadly stated in the empirical literature (Hoesli (2004), Wu and Pandey (2012) and Peat and Wright (2012) among others). It indicates that adding residential property in a multi-asset portfolio would increase its efficiency. On the other hand, it appears to be a positive and significative relationship between cash and housing (correlations are between 0.49 and 0.65). In the meanwhile, correlation between housing asset groups is highly and significantly positive. However, even though there is no clear divergent housing sub-market, we notice that the first group (the core group constituted mainly by central districts of Paris proper) is slightly less correlated to groups four and five (77% and 75%).

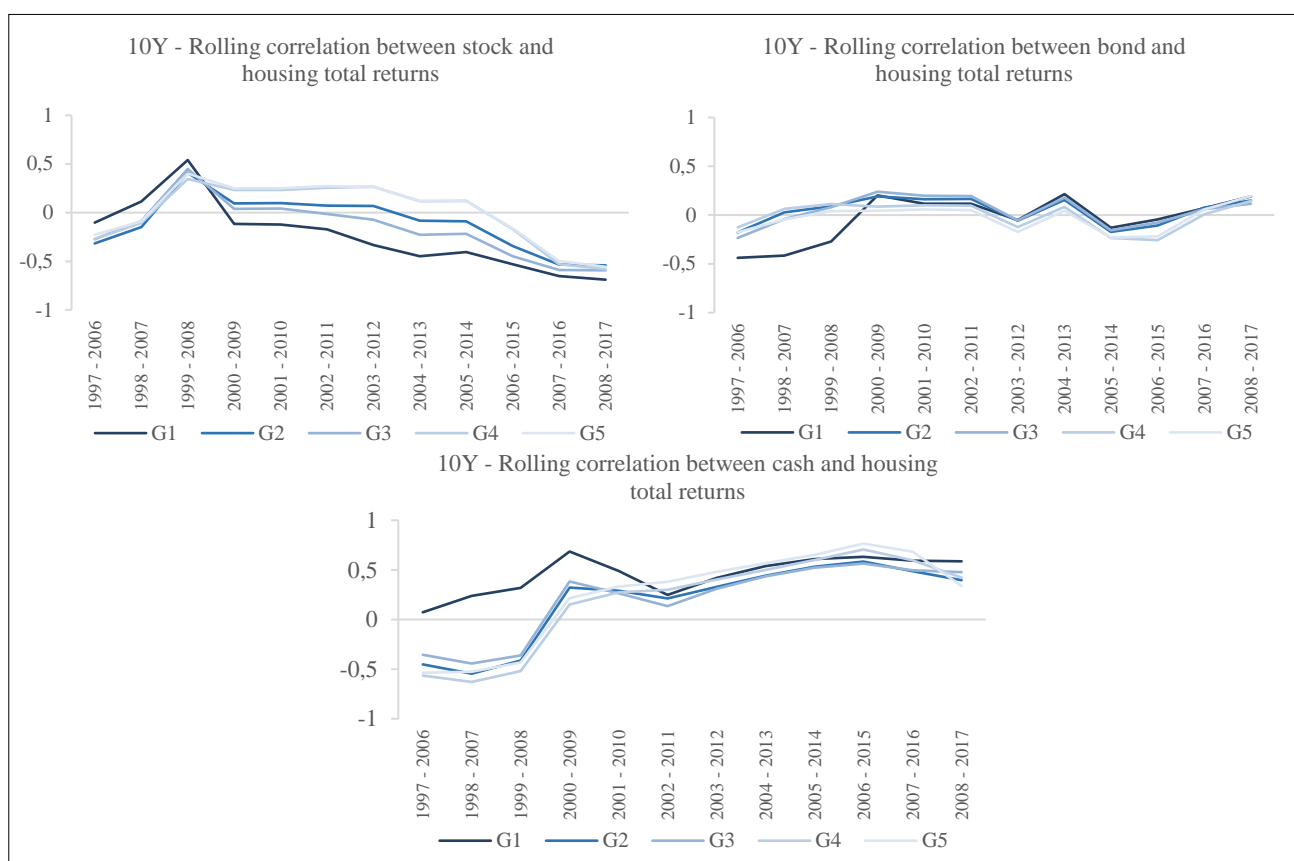
**Table 3.** Correlation between various asset classes returns, 1997 – 2017

	Stock	Bond	Cash	Group 1	Group 2	Group 3	Group 4	Group 5
Stock	1							
Bond	-0.3705	1						
Cash	-0.0529	0.0582	1					
Group 1	-0.2109	-0.0379	0.6560*	1				
Group 2	-0.1638	0.0159	0.5339*	0.9023*	1			
Group 3	-0.1998	-0.0078	0.5454*	0.9484*	0.9851*	1		
Group 4	-0.0996	0.0066	0.4963*	0.7712*	0.9534*	0.9024*	1	
Group 5	-0.0810	-0.0150	0.5193*	0.7581*	0.9405*	0.8873*	0.9879*	1

Correlations however may not be stable over the entire sample period. Results in figure 4 reveal shifts in trends among some assets. For example, correlations between the five groups housing assets and stock appear to have decreased steadily and markedly after 2008, after reaching a pic between 1997 – 2006 and 1999 – 2008. On the contrary, correlations between housing assets and cash have followed a continuous upward trend from the beginning, shifting from a negative relationship prior to 2000 – 2009 to a positive correlation thereafter. The correlation of housing with bond has remained relatively stable slightly above or below zero. The first housing group has always the strongest average pairwise correlation with financial assets compared to other housing groups, either positive (0,65 with cash) or negative (-0.21 with stock and -0.03 with bond). The latter attests the higher disconnection between the residential market in these communes, compared to other communes, and the state of financial markets.

To conclude, we notice that correlations between the five groups housing assets and stock, bond and cash may be unstable over time but, except for cash asset, it never appears strongly positive or negative. This result corroborates the diversification ability of housing in a mixed asset portfolio.

**Figure 4.** Rolling correlations between housing returns and other asset classes returns



### 4.3. Inflation hedgeability

A number of studies from several countries have proved that real estate and housing in particular provides a solid hedge against inflation. To complete our analysis of the French direct housing investment, we examine and compare the hedging ability of stock, bond, cash and five groups housing assets total returns against inflation. For this purpose, we first undertake a correlation analysis, then a regression following Fama and Schwert methodology (1977).

#### 4.3.1. Correlation analysis

The inflation hedging feature can be examined through an analysis of the correlation between assets classes returns and inflation<sup>8</sup>. Table 4 presents these correlations over the sample period.

Stock is negatively and significantly correlated to inflation (-0.54), meaning that it is not able to provide any hedge against inflation. But more than that, it even acts as perverse hedge against inflation. Bond is positively correlated with inflation. However, the coefficient is quite low and statistically non-significant (0.38). This is also the case for cash which is positively but non-significantly correlated to inflation (0.3). On the contrary, housing exhibits a significant co-movement with inflation. The five groups housing assets total returns are positively correlated with inflation. Considering that total return is composed by two components; capital return and income return, we sought to investigate which one drives this considerable hedge against inflation.

<sup>8</sup> The Consumer Price Index is used as a proxy for inflation

**Table 4.** Correlation between inflation and various assets' returns

	<b>Inflation</b>
<b>Stock</b>	-0.5365*
<b>Bond</b>	0.3085
<b>Cash</b>	0.3846
<b>Group 1 – Total return</b>	0.6253*
<b>Group 1 – Capital appreciation</b>	0.6711*
<b>Group 1 – Income return</b>	-0.0344
<b>Group 2 – Total return</b>	0.6377*
<b>Group 2 – Capital appreciation</b>	0.6981*
<b>Group 2 – Income return</b>	-0.0314
<b>Group 3 – Total return</b>	0.6415*
<b>Group 3 – Capital appreciation</b>	0.7022*
<b>Group 3 – Income return</b>	-0.0090
<b>Group 4 – Total return</b>	0.5783*
<b>Group 4 – Capital appreciation</b>	0.6292*
<b>Group 4 – Income return</b>	-0.0394
<b>Group 5 – Total return</b>	0.5661*
<b>Group 5 – Capital appreciation</b>	0.6092*
<b>Group 5 – Income return</b>	0.0003

According to the results in table 4, significant positive correlations are found for capital returns, and negative and insignificant ones for income returns.

To conclude, the five groups housing assets total returns correlations with inflation seem to be driven by their capital return components, since both correlate very similarly with inflation. This is may be due to the fact that rents were first indexed to the ICC (Index of Construction Cost), then to the IRL (*Indice de Révision des Loyers*) which was until 2008 only partly based on the CPI (Consumer Price Index, proxy of the inflation)<sup>9</sup>. These results are similar to those recorded in Canada by Le Moigne and Viveiros (2008), who found that the capital return is the main source of inflation exposure for total real estate returns between 1973 and 2007.

Correlation between inflation and various assets returns may not be stable over time. We run thus rolling correlation analysis that leads to similar results as above (Available upon request).

#### **4.3.2. Regression analysis**

To test the hedging ability of French housing assets against inflation, in addition to the correlation analysis, we run a regression designed to quantify the relationship between the five groups housing assets returns and movements in inflation. In this part, we examine the effectiveness of the various asset classes as hedges against actual, expected and unexpected inflation. We followed the approach proposed by Fama and Schwert in 1977.

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<sup>9</sup> The index IRL was initially composed for 40% of the index of construction cost (ICC) and the price index for housing maintenance and improvements (IPEA), and for 60% of the consumer price index (proxy of inflation). Then its composition has changed since 2008 to be based only on the annual moving average of the consumer price index.

They used a two-factor model in which the asset return is the dependent variable and both expected and unexpected inflation are the independent variables.

$$R_t = \alpha + \beta(E(\text{inf}_t)) + \gamma(\text{inf}_t - E(\text{inf}_t)) + \varepsilon_t \quad (1)$$

Where  $R_t$  is the return of an asset in period  $t$ ,  $E(\text{inf}_t)$  is the expected inflation for period  $t$ ,  $(\text{inf}_t - E(\text{inf}_t))$  is the unexpected inflation which is the difference between actual and expected inflation for period  $t$  and  $\varepsilon_t$  is the error term.

The asset is a greater positive hedge against inflation as the coefficients  $\beta$  and  $\gamma$  increase. Therefore, according to the coefficients  $\beta$  and  $\gamma$ , one can assess either the asset is a complete, partial, perverse or over hedge against expected and unexpected inflation.

We followed the assumption of Hamelink and Hoesli (1996): the expected inflation is inferred from past actual inflation. The unexpected component is the difference between the two (the actual and expected inflation). By assuming that expected inflation at a time  $t$  is a linear function of the expected inflation at time  $t-1$ , we get this relation:

$$\text{inf}_t = \alpha + \beta(\text{inf}_{t-1}) + \varepsilon_t \quad (2)$$

Where  $\text{inf}_t$  is the expected inflation for period  $t$ ,  $\text{inf}_{t-1}$  is the actual inflation for period  $t-1$  and  $\varepsilon_t$  is the error term. Using the estimates for inflation from the equation (2) above, we compute the values of expected inflation (the fitted values) and the unexpected inflation (actual inflation minus expected inflation). The results of the regression presented in equation (1) are displayed in table 5.

**Table 5.** Regression results of various asset classes on expected and unexpected inflation

Variables	Stock	Bond	Cash	G1	G2	G3	G4	G5
Exp_inf	-13.00 (-0.47)	0.02 (0.0)	0.05 (0.04)	-1.51 (0.22)	5.28 (0.92)	3.51 (0.51)	7.22 (1.39)	7.82 (1.26)
Unexp_inf	-19.13*** (-3.25)	4.2 * (1.94)	0.28 * (1.13)	3.77 ** (2.56)	3.37 ** (2.74)	3.68 ** (2.49)	2.84 ** (2.56)	2.99 ** (2.26)
Constant	0.01 (-0.28)	0.00 (0.11)	0.00 (-0.9)	-0.01 (1.62)	0.00 (-0.38)	0.11 (-0.37)	0.00 (-0.36)	0.00 (-0.24)
R <sup>2</sup>	0.48	0.28	0.11	0.38	0.36	0.34	0.31	0.25

Generally, results are consistent with conclusions frequently drawn from the empirical literature concerning the ability of housing to provide the strongest hedge against inflation, compared to other asset classes. However, in our case, the hedging ability concerns only the unexpected component of inflation<sup>10</sup>. Actually, the coefficients for expected inflation are mixed in sign (positive for six asset

<sup>10</sup> The hedging ability of almost all our asset classes against unexpected inflation is somewhat surprising. This might be due to the methodology used to decompose the inflation into two components. Such a conclusion may not hold if we follow another methodology for proxying actual inflation, and decomposing it into expected and unexpected components.

groups and negative for the remainder of asset groups) and not significant<sup>11</sup>. All the five housing groups assets were found to act as highly positive hedge against unexpected inflation. Further, cash and bond were found to provide respectively a partial and an over hedge against unexpected inflation. Stock acts as a perverse hedge against unexpected inflation and provides no significant hedge against expected inflation.

## 5. Portfolio optimization

The main objective of this section is to examine the weight given to direct housing asset in mean variance optimized portfolios with four asset classes: stock, bond, cash and direct housing. This section is organized as follow: we first briefly present the optimization technique we use, then we present sequentially the obtained results for the 127 communes and for the five groups of communes, considered as potential direct housing investment.

### 5.1. Optimal asset allocation

There have been considerable advances in asset allocation literature starting with the path breaking work of Markowitz (1952). This author provided the seminal theoretical work to the asset allocation when investors' decisions are driven only by the expected return and the volatility of a portfolio's return. Despite its limitations<sup>12</sup>, the mean-variance approach is still one of the most important benchmark models used in practice (Litterman (2003), Meucci (2005), Campbell (2007), Bilir (2016)). In this context, our paper uses the mean-variance framework to bring answers regarding optimal portfolio allocation when considering, besides stock, bond and cash, investment in direct housing in one or a group of communes of the *Grand Paris*. We consider two major *scenarii* of assets included in the portfolio:

Scenario 1: [%Stock ; %Bond ; %Cash ; % One commune among 127 communes]

Scenario 2: [%Stock ; %Bond ; %Cash ; % One group of communes among 5 groups]

The first scenario results in 127 different portfolios and the second scenario results in 5 different portfolios. Considering that for each portfolio, the optimal combination of risky assets is the one that provides the highest Sharpe ratio (i.e. the highest excess return per unit of risk), we then construct tangency portfolios for each combination of assets by optimizing assets weights to maximize the Sharpe ratio:

$$\max \frac{\mu_{p,w} - r_f}{\sigma_{p,w}} \text{ s. t. } \sum w_a = 1 \text{ and } w_a \geq 0$$

Where  $\mu_{p,w}$  and  $\sigma_{p,w}$  are respectively the mean and the standard deviation of portfolio return over the sample period,  $r_f$  is the average risk-free rate<sup>13</sup>. The optimization of asset weights in each portfolio is

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<sup>11</sup> When positive, insignificant coefficients can also demonstrate a potential for hedging, although not as strong as significant positive coefficients.

<sup>12</sup> Some assumptions do not correspond to the reality, such as the fact that liquidity is infinite, all investors are rational and risk adverse, investors control risk only by the diversification of their holdings, etc.

<sup>13</sup> The risk-free rate considered in the study is the average OAT 10 years French bond over the 2000-2017 period. It is commonly used in the real estate industry as the benchmark to which we compare real estate returns (Crédit Foncier, BNP Real Estate, etc.).

conducted such that the portfolio is fully invested (the sum of all assets' weights equals one) and no short sale is allowed (each asset weight is equal or greater to 0).

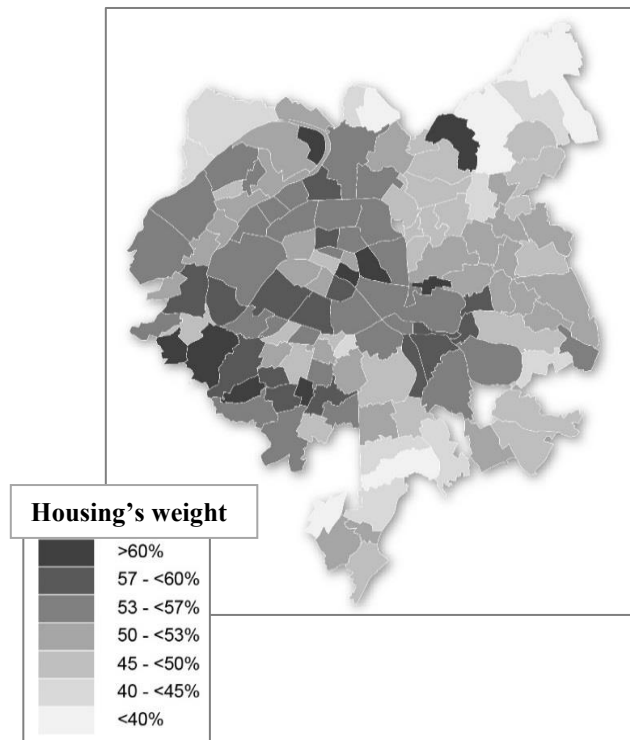
**5.2. Optimal asset allocation for the first scenario: 127 communes in the Greater Paris area**

Detailed results per commune over the whole sample period 1997 – 2017 is shown in figure 5<sup>14</sup>. For instance, the tangency portfolio of an investor who invested in the first district of Paris is composed by 10.85% in stock, 40.13% in bond and 49% in direct housing in this commune. Similarly, when investing in *Saint-Denis*, the iconic host city for the Games, the tangency portfolio is composed by 9.71% in stock, 36.29% in bond and 53.98% in direct housing in this commune.

**Figure 5.** Asset allocation for the 127 communes when considering stock, bond, cash and direct housing



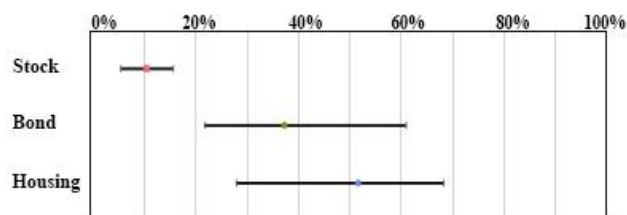
<sup>14</sup> Only Stock, bond and housing are represented because cash did not appear in the tangency portfolio. This could be explained by the characteristics of the proxy used for the cash; Euribor 3 months. As seen before, it provides the weakest return and it is the most positively correlated asset with housing asset. In contrast, due to its lowest volatility among other assets, it captures the highest share of the minimum variance portfolio, while no housing asset appears in the minimum variance portfolio. That is why we made the choice to present only the tangency portfolio.



A complementary summary of the portfolios allocations is presented below in figure 6. Globally, the latter confirms that in France and more precisely in the Parisian great area, the housing asset is given a considerable weight ranging between 28% and 68% of the portfolio, depending on the commune we invested in, with a mean weight over the entire sample of 52%. It is followed by bond with a range between 21% and 61% and a mean weight of 37%. Stock carries a small weight between 6% and 16% with a mean weight of 11%<sup>15</sup>. Exceptions exist in some cases, such that the tangency portfolio is heavily weighted toward bond instead of housing, but the stock never held the majority position. For example, the case of *Morangis* (10.96% in stock, 60.7% in bond and 28.32% in direct housing in this commune), or *Villeneuve-le-Roi* (8.5% in stock, 52.34% in bond and 39.13% in direct housing in this commune).

These results are consistent with findings in the literature about direct real estate allocation within Sharpe maximizing portfolio. For example, Fisher *et al.* (2007) who used Sharpe maximizing portfolio and also transaction-based index, found allocation toward real estate of approximately the same magnitude than our results (on average 43%).

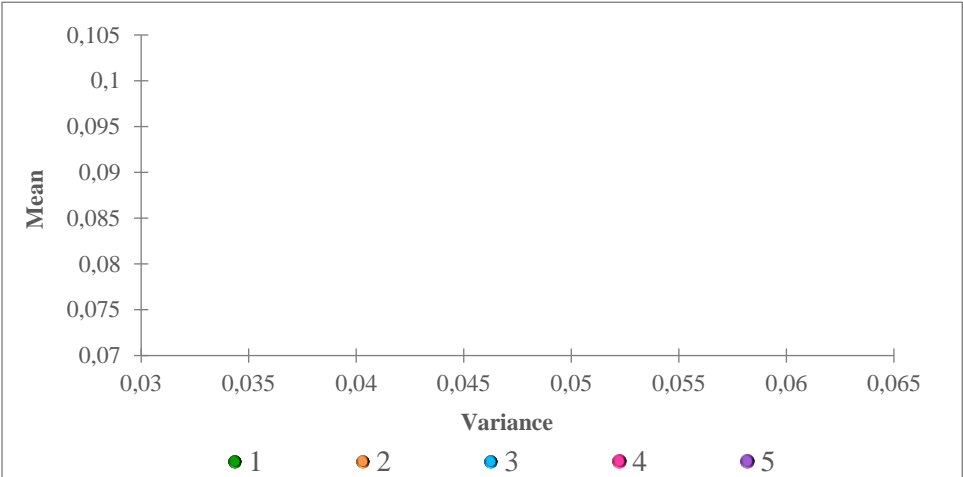
**Figure 6.** Portfolios allocation weights ranges



<sup>15</sup> Although this share is the lowest within the tangency portfolio, it is important to note that it is still higher than what is actually observed amongst the wealth of French households, according to the bulletin of Banque de France, 2017.



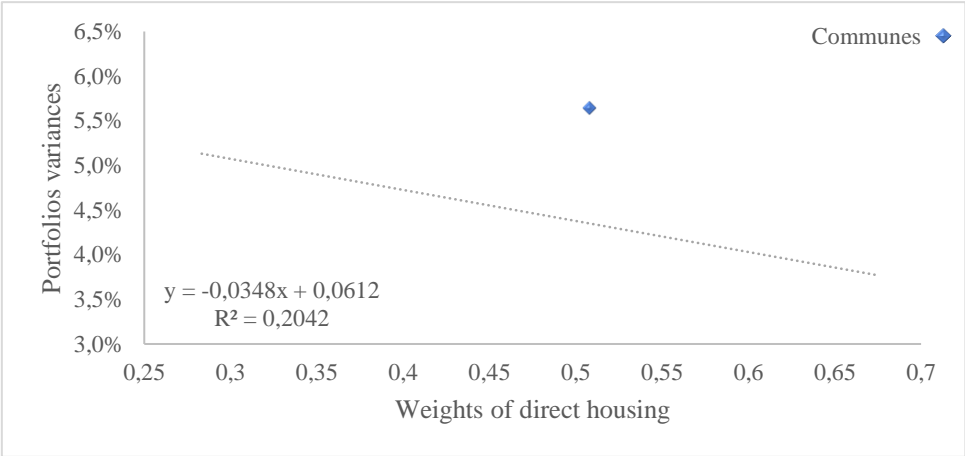
The corresponding mean variance characteristics of all obtained portfolios are represented in figure 7. Portfolios returns range between 7.5% and 9.94%, and variances range between 3.39% and 6.42%. Among the 127 portfolios, figure 7 indicates their belonging to the five housing groups. We notice coherent risk/return profiles among the communes of each group. In other words, one can notice that the communes of group 1 are the safest ones with low levels of returns, followed by the communes of group 2 and 3, little riskier but offering higher returns. Communes of group 4 and 5 share approximately same level of risk, but all the communes of group 5 offer higher returns than group 4, and the highest return more generally.



**Figure 71.** Risk-Return profiles of the 127 portfolios belonging to the five housing groups

The housing asset is recognized as portfolio diversifier with a substantial reduction of total risk of the portfolio. We represent in figure 8 the scatter plot of the 127 allocations towards housing and the variances of corresponding portfolios. When constraining the portfolios to be the tangency ones, we notice that the higher is the share allocated toward direct housing in a portfolio, the less is the variance of the latter. This is in line with findings in previous sections (literature review and data analysis), such that housing is a good candidate for enhancing portfolio performances and diversification purposes.

**Figure 8.** Housing allocation in the 127 communes and corresponding portfolios variances



### 5.3. Optimal asset allocation for the second scenario: five groups of communes in the Greater Paris area

Portfolios optimization were also run for the five groups of communes created using the A.H.C technique. Table 6 summarizes the results for the five obtained portfolios.

Differences are quite subtle in allocations and so are performances among the five groups. However, it is noteworthy that in all groups, housing is predominant (which was not the case for many individual communes) with an average share of 55%, followed by bond (33%) and stock (10%). This result is different from Delfim and Hoesli (2019) who find, using US data over three decades, that medium- to long-term investors should allocate 10% to 20% of their portfolio to direct real estate.

	Group 1	Group 2	Group 3	Group 4	Group 5
Mean	8.18%	8.45%	8.75%	8.58%	9.39%
Variance	3.66%	3.87%	3.84%	4.21%	4.40%
Housing weight	55.07%	58.86%	56.72%	54.37%	54.32%
Bond weight	34.25%	31.12%	32.61%	35.45%	35.84%
Stock weight	10.68%	10.02%	10.67%	10.18%	9.84%

**Table 6.** Stock, bond and five housing groups' tangency portfolios

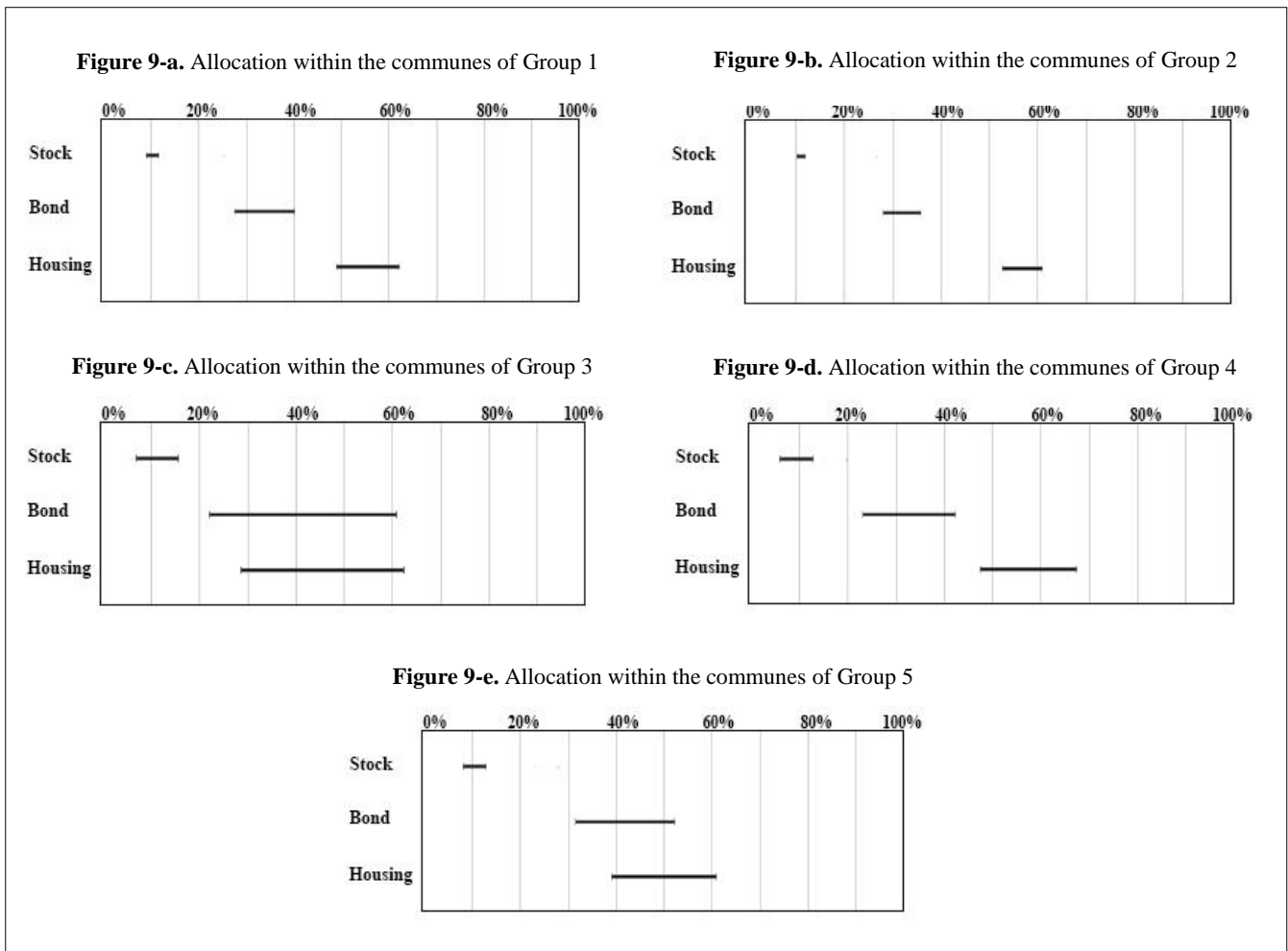
Figure 9 displays the optimal weights (in ranges) in the tangency portfolio when including the five groups as the potential direct housing asset. It represents a synthetic view of the corresponding optimal weights for each one of the considered assets. For instance, figure 9-a shows optimal assets' weights when investing in direct housing within group 1: stocks optimal weight ranges between 9% and 12%, bonds share ranges between 27% and 40% whereas Group 1 direct housing optimal weight is between 49% and 62%. Moreover, when viewing the different subfigures of figure 9 (9-a-b-c-d-e), one can notice that the weights ranges of the direct housing asset vary from a group of communes to another. Taking the examples of groups 2 and 3, the optimal direct housing weight ranges from 52% and 61% for group 2 while it ranges from 29% to 62% for group 3. This observation can be attributed to the individual and differentiated evolutions of each commune within each group from 2000 to 2017<sup>16</sup>. Consequently, when deciding to invest in a particular commune, one should always refer to the commune's appropriate optimal weight.

## 6. Robustness check

This section consists in a further analysis about portfolio allocation, focusing mainly on the check of stability of portfolios allocations and second on the diversification achieved through the inclusion of direct housing assets. Moreover, all precedent tests were also conducted considering listed real estate (*Société d'investissement en immobilier coté, SIIC*).

<sup>16</sup> Besides, for visual representation, we chose to classify the existing communes into 5 homogenous groups only. Classifying them into more groups would have led to more precise weights.

**Figure 9. Portfolios allocations**



**6.1. Portfolio allocation over ten years rolling windows**

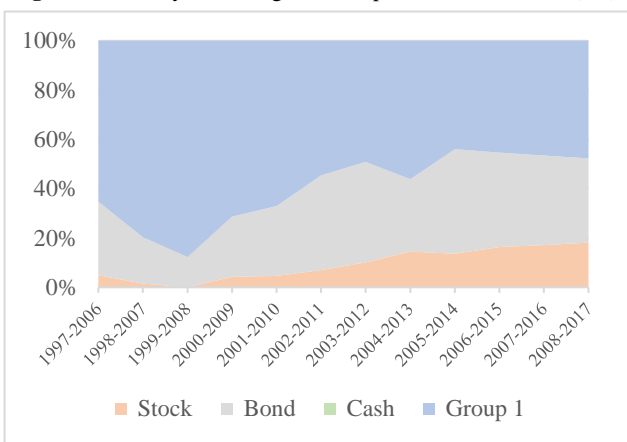
The advantage of reducing the number of direct housing assets to five is the handiness of data and better visual representations. Thus, we choose to use the five groups of communes that represent direct investment in housing instead of the 127 individual communes.

In this section, we aim to challenge the stability of housing allocation within the multi-asset optimal portfolio. To reach that goal, we perform portfolio optimization by using ten-year rolling windows of data. According to our sample, we get 12 holding periods: 1997 – 2006; 1998 – 2007; 1999 – 2008; ...; 2008 – 2017. Figures 10-a to 10-e show the portfolios allocations for the five groups. Results show that cash appeared only during the four first holding periods in the portfolios invested in the groups 2 to 5, in addition to stock and bond. Then the allocation toward cash became null for all groups. This declining tendency might be due to the fact that the Euribor 3months levels dropped from around 7% in 1997 to almost zero starting from 2013 according to the European Central Bank. Cash did not appear in the portfolio optimal composition invested in group 1’s housing asset. Regarding stocks, we notice a minor and variant weight in the optimal portfolio during the several observed periods of the moving window. This variation can be a result of the changing economic context. We thus observe that stocks optimal weight is quasi null during turmoil periods, i.e. subprime crisis and sovereign debt crisis. Moreover, bonds have significantly increased in all portfolios since the 1999 – 2008 rolling

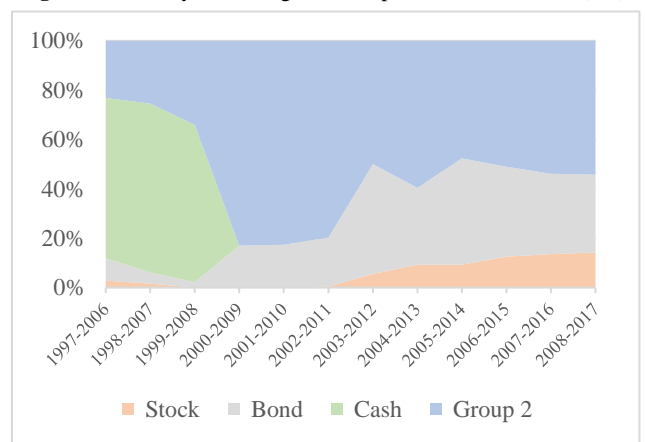
window. This could be due on one hand initially to a replacement of cash allocation by a bond allocation due to the declining reward of cash. On the other hand, and with the collapse of the subprime crisis, investors became more reluctant to risk taking which translates into a heavier weight of bonds instead of stocks. In the meanwhile, direct housing weights changed overtime as well but according to different paths for each group of communes. Indeed, whereas groups 1, 2 and 3 weights increased initially then stabilize around 50% starting from 2003 – 2012, groups 4 and 5 weights continue their progress after 2005 – 2014 to settle around 60% during the last holding period. In all cases, we notice that direct housing catches always the most important part of the optimal portfolio.

**Figure10.** Rolling portfolios optimization

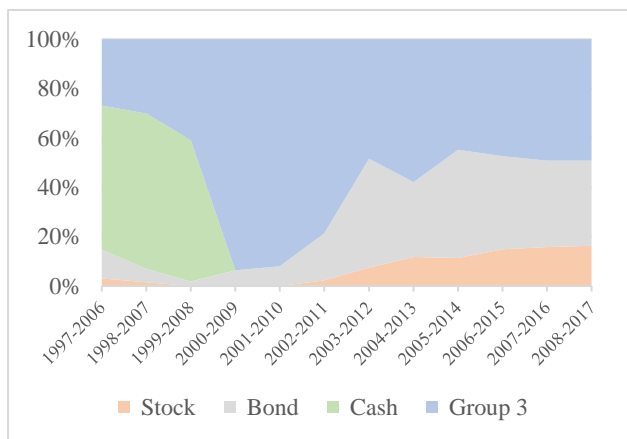
**Figure 10-a.** 10-year rolling window portfolio allocations (G1)



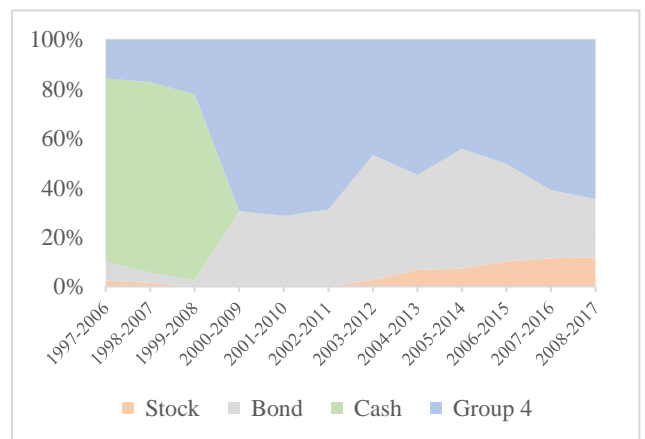
**Figure 10-b.** 10-year rolling window portfolio allocations (G2)



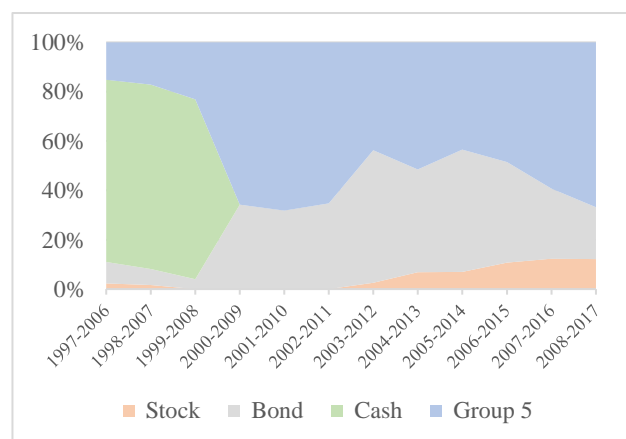
**Figure 10-c.** 10-year rolling window portfolio allocations (G3)



**Figure 10-d.** 10-year rolling window portfolio allocations (G4)



**Figure 10-e.** 10-year rolling window portfolio allocations (G5)



## 6.2. Efficient frontiers and the impact of housing within a multi-asset portfolio

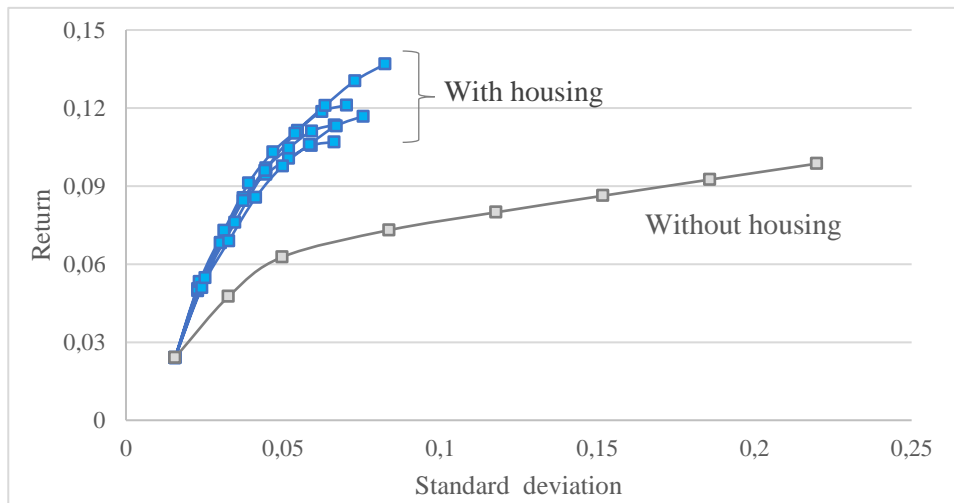
In order to evaluate the impact of housing, we construct in a mean variance coordinate system the efficient frontiers for portfolio composed by financial assets only (stock, bond and cash) and portfolios where housing is added. For reasons of clear presentations, we present the results for 6 efficient frontiers: one with financial assets only and five corresponding to the portfolios that are invested, besides the financial assets, in each one the five groups of communes (figure 11).

We notice that portfolios that include housing systematically outperform the classical financial portfolio. Comparing the efficient frontiers supports the argument that housing enhances portfolio performances; it increases portfolio return for a given level of risk, or inversely it reduces the portfolio risk for a given level of return.

Table 7 summarizes results about portfolios optimal allocations for different levels of return and the corresponding minimized risk. We notice that, whatever considered housing group, adding housing in a portfolio effectively reduces its risk. For example, at 5% return, including housing decreases the risk of the portfolio from 3.5% to 2.2% (when including G3); 2.3% (when including G1, G2 and G5) and 2.4% (when including G4). We also notice that the share of housing is increasing when the returns increase, while always generating a lower risk. For example, at a return of 5%, the share of housing is between 15% - 20% (portfolios are heavily allocated towards cash). At a return of 7%, the share of housing is between 28% and 35%. Finally, at a return of 9%, the share of housing becomes substantial, fluctuating between 47% and 58%.

To conclude, these figures confirm the role of housing within a multi-asset portfolio in terms of risk-reduction and performance enhancement.

**Figure21.** Efficient frontiers with and without housing, 1997 – 2017



**Table 7.** Portfolios optimal allocation for different levels of returns and risks, 1997 – 2017

	Risk (%)	Stock (%)	Bond (%)	Cash (%)	Housing (%)
Return = 5%					
Portfolio without housing	3.5	12.3	57.4	30.3	-
Portfolio with housing (group 1)	2.3	5.8	24.1	50.7	19.4
Portfolio with housing (group 2)	2.3	5.3	21.8	53.6	19.4

Portfolio with housing (group 3)	2.2	5.4	21.8	55.0	17.8
Portfolio with housing (group 4)	2.4	5.4	23.9	52.9	17.8
Portfolio with housing (group 5)	2.3	5.0	23.0	56.7	15.3
Return = 7%					
Portfolio without housing	7.0	33.9	66.1	0.0	-
Portfolio with housing (group 1)	3.1	8.5	34.3	21.3	35.8
Portfolio with housing (group 2)	3.1	7.7	30.8	26.2	35.3
Portfolio with housing (group 3)	3.0	7.9	30.9	28.7	32.5
Portfolio with housing (group 4)	3.3	7.9	34.5	25.0	32.6
Portfolio with housing (group 5)	3.2	7.2	32.7	32.1	28.0
Return = 9%					
Portfolio without housing	17.2	80.1	19.9	0.0	-
Portfolio with housing (group 1)	4.0	10.8	31.1	0.0	58.2
Portfolio with housing (group 2)	4.0	10.0	37.9	0.0	52.1
Portfolio with housing (group 3)	3.9	10.4	40.0	2.4	47.2
Portfolio with housing (group 4)	4.4	10.2	40.6	0.0	49.2
Portfolio with housing (group 5)	4.7	0.0	42.2	10.7	47.1

### 6.3. Introduction of securitized real estate in a multi asset portfolio

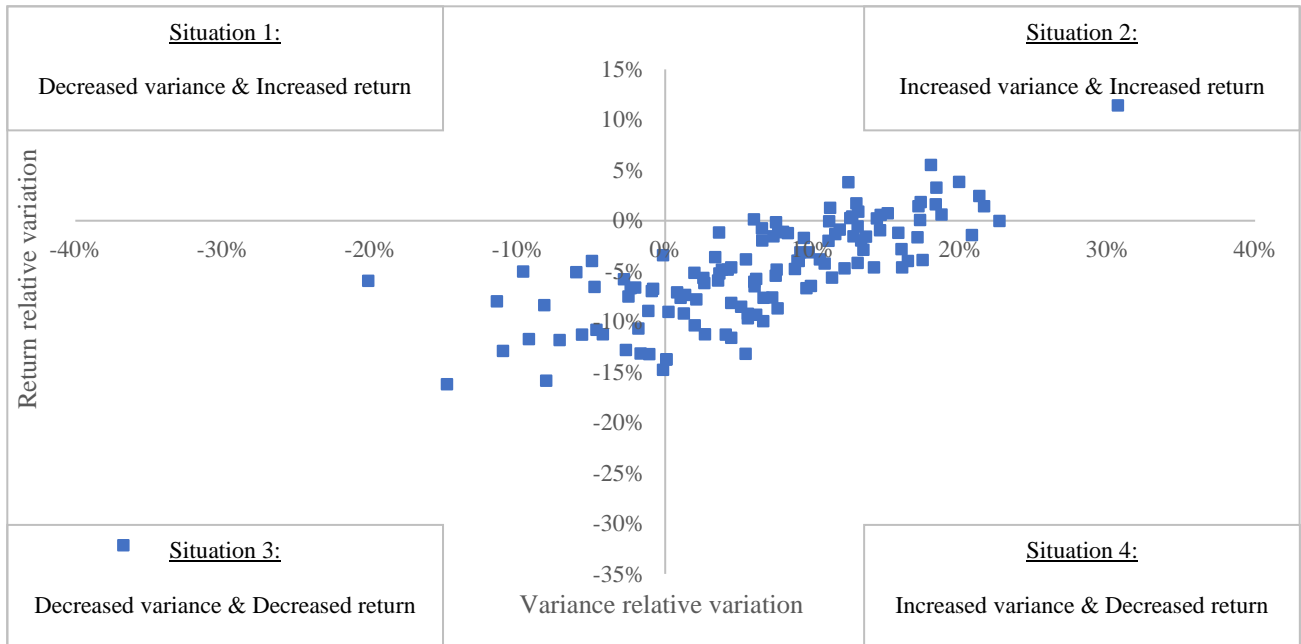
Even though indirect real estate investment is outside the scope of our study, we briefly introduce this way of allocation in real estate within a multi-asset portfolio. Actually, investment in real estate can be made not only through direct ownership of buildings, but also through investment in listed or non-listed real estate funds.

The Euronext IEIF SIIC index is selected to represent indirect listed real estate investment. It is produced by the IEIF (*Institut de l'Epargne Immobilière et Foncière*) since December 2002 on a daily basis. It measures the performance of all property companies' stocks listed on Euronext's regulated markets in Paris and which have opted for the tax-transparency regime SIIC (*Sociétés d'Investissement Immobilier Cotées*). We consider the annual frequency from 2002 to 2017 to match our initial data base that already includes the four other asset classes (stock, bond, cash and direct housing). The average annual total return of the SIIC index is 15.08% and the standard deviation is 25.57%. Correlation analysis show that SIIC index is highly and significantly correlated to stock, this confirms the often advanced about the stock component existing in securitized real estate such as SIIC. We also notice a very low and non-significant correlation between direct and indirect real estate in the French context<sup>17</sup>. Using portfolio optimization technique, we find that adding SIIC in a mixed asset portfolio does not improve its overall performance, the bulk of our 127 portfolios saw their return lowered and risk increased. Our findings are consistent with Delfim and Hoesli (2019) who find that REITs (United States Market) are usually of limited interest as a substitute for direct real estate, but they could be used in conjunction with direct investments for medium- and long-term horizons. It is worthy to note however that we test the inclusion of SIIC only in portfolios that maximize the Sharpe ratio<sup>18</sup>. A synthetic view about the variations of portfolios' variances and returns is given in figure 12.

<sup>17</sup> Detailed results are available upon request.

<sup>18</sup> Results may be different for other optimization constraints (such as more risk averse portfolios or portfolios seeking for higher returns).

**Figure 12.** Impact of SIIC inclusion on portfolios' risks and returns, 1997 – 2017



## 7. Conclusion

This study provides an overview of the role of direct housing investment within a mixed-asset portfolio. The particularly favorable French context enabled this asset class to distinguish itself in several ways. Along with 2024 Olympic Games, the Greater Paris area is part of an urban development project that consists among others in an upgrade of its whole transport network. Consequently, given both ongoing and future infrastructure projects and transportation network expansion, the Greater Paris region is currently experiencing a genuine urban renewal that strongly contributes to its growing attractiveness. Furthermore, housing market fundamentals<sup>19</sup> are favorable to direct investment in housing. With an important stock of dwellings (i.e. investment opportunities) and a considerable rental market size, a buy-to-let housing investment is encouraged since the vacancy risk, which may lead to irregular cash flows, is reduced. Then, using a mean-variance efficiency framework and yearly data from 1996 to 2017, this study evaluates the portfolio allocation toward four asset classes: stock, bond, cash and direct housing. Housing is represented by the investment opportunities in the 127 communes of the studied area. In concordance with previous empirical findings, the direct housing asset is given a considerable weight in the portfolio that maximizes the Sharpe ratio. Not only does the residential asset displays low level of return volatility compared to other asset classes, while providing higher returns, but also the correlation analysis which is central to the asset allocation decision confirm the characteristic of the housing asset as a relevant portfolio diversifier. Actually, we find that correlation between housing and other asset classes are either weak or non-significant, which means that adding housing to traditional financial assets portfolio can enhance its performance. As a result, all the

<sup>19</sup> Detailed analysis of the Greater Paris area housing market fundamentals is available upon request.

portfolios on the efficient frontier (except the minimum variance portfolio which is heavily weighted toward cash) tend to contain substantial proportions of housing, and the efficient frontier containing housing systematically dominates the one that excludes housing as an asset class. Besides this diversification potential, correlation and regression analysis were conducted to evaluate the relationship between housing returns and inflation. In line with the extensive literature, positive relationship is found between direct housing returns and CPI (which is used to proxy inflation), making the residential asset interesting to hold to hedge against inflation. As to test the robustness of our finding, we conduct rolling window analysis to check for weights stability and find that direct housing optimal weight can vary in time but it is always the asset that beneficiaries form the highest weight. Moreover, we test the impact of introducing direct real estate in a financial portfolio. Our results confirm the role of housing within a multi-asset portfolio in terms of risk-reduction and performance enhancement. Furthermore, we introduce the indirect real estate as an asset class within a mixed-asset portfolio. The SIIC index is used for this purpose. Results indicate that the latter is highly and significantly correlated to stock, while it displays a very low and non-significant correlation with the direct housing asset. When it comes to portfolio allocation decision, we show that adding SIIC in a mixed asset portfolio does not neither improve its overall performance nor reduces its risk. Besides, it does not reduces the allocation towards direct real estate.

Finally, it is worthy to remind that the results of the study should be considered in light of its shortcomings. First, the analysis conducted relies on short and low frequency time series, which may weaken the obtained results. Second, when computing assets' returns, no tax benefits, transaction costs, additional costs (maintenance, management, etc.), risk premiums (rental vacancy, illiquidity, etc.) were taken into consideration, although they would impact assets' performances. Future research should overcome this shortcoming by adjusting the returns series according to French local markets conditions and prevailing usages (see for example the study of Hoesli et al., 2007, that applied a fixed liquidity premium of 150 basis points to the housing returns series in Switzerland). Finally, we use Markowitz model in the computation of optimal portfolio allocation. This model remain widely used because of its simplicity in spite of the numerous criticism addressed to the latter.



**Appendix 1.** Description of the variables used in the A.H.C

Variables		Description	Source
<b>Housing market fundamentals</b>	Price	Annual prices of collective houses between 1996-2017 in 150 communes	- The chamber of Notaries in Île-de-France
	Rent	Annual rent of houses between 2000-2017 in 150 communes, completed by the index of rent in Paris between 1996- 2000	- CLAMEUR ( <i>Connaître les Loyers et Analyser les marchés dans les Espaces Ruraux et Urbains</i> ) - OLAP ( <i>Observatoire des Loyers dans l'Agglomération Parisienne</i> )
	Stock	Numbers of collective houses in 127 communes in 2009 and 2014  & annual number of households between 1996-2017	- INSEE ( <i>Institut National de la Statistique et des Etudes économiques</i> ) - DGFP ( <i>Direction Générale de la Finance Publique</i> )
<b>Housing market dynamism</b>	Population size	Annual population size between 2000-2014 in 127 communes, completed by annual population size at a departmental level between 1996-2000, and 2014-2017	- INSEE ( <i>Institut National de la Statistique et des Etudes économiques</i> ) - OXFORD ECONOMICS
	Income	Annual medium income in 127 communes between 2003-2015, completed by annual medium income at a departmental level between 1996-2002 and 2016-2017	- DGFP ( <i>Direction Générale de la Finance Publique</i> ) - OXFORD ECONOMICS
<b>Investors profile</b>	Total return	Annual total return between 1996-2017 in 127 communes composed by capital gain & income return	- The chamber of Notaries in Île-de-France - CLAMEUR
	Risk	Variance and standard variation of the annual total return in 127 communes	- MACROBOND - BNPPRE calculation

	Sharp ratio	The excess residential return in 127 communes over the yield of OAT 10years adjusted to their risks.	
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**Appendix 2.** Detailed list and description of the communes within the five housing groups resulting from the A.H.C

<b>Group 1</b>	<b>Group 2</b>	<b>Group 3</b>	<b>Group 4</b>	<b>Group 5</b>
1 <sup>st</sup> District	9 <sup>th</sup> District	11 <sup>th</sup> District	Athis-Mons	Clichy
2 <sup>nd</sup> District	10 <sup>th</sup> District	12 <sup>th</sup> District	Juvisy-sur-Orge	Gennevilliers
3 <sup>rd</sup> District	Antony	13 <sup>th</sup> District	Morangis	Villeneuve-la-Garenne
4 <sup>th</sup> District	Bois-Colombes	14 <sup>th</sup> District	Savigny-sur-Orge	Aubervilliers
5 <sup>th</sup> District	Boulogne-Billancourt	15 <sup>th</sup> District	Viry-Châtillon	Aulnay-sous-Bois
6 <sup>th</sup> District	Bourg-la-Reine	17 <sup>th</sup> District	Asnières-sur-Seine	Bagnolet
7 <sup>th</sup> District	Châtenay-Malabry	18 <sup>th</sup> District	Bagneux	Le Blanc-Mesnil
8 <sup>th</sup> District	Châtillon	19 <sup>th</sup> District	Colombes	Bobigny
16 <sup>th</sup> District	Chaville	20 <sup>th</sup> District	La Garenne-Colombes	La Courneuve
Neuilly-sur-Seine	Clamart		Malakoff	Épinay-sur-Seine
	Courbevoie		Nanterre	Montreuil
	Fontenay-aux-Roses		Puteaux	Pantin
	Garches		Bondy	Pierrefitte-sur-Seine
	Issy-les-Moulineaux		Le Bourget	Romainville
	Levallois-Perret		Drancy	Saint-Denis
	Meudon		Gagny	Saint-Ouen
	Montrouge		Les Lilas	Stains
	Le Plessis-Robinson		Livry-Gargan	Orly
	Rueil-Malmaison		Neuilly-Plaisance	Villeneuve-le-Roi
	Saint-Cloud		Neuilly-sur-Marne	Villeneuve-Saint-Georges
	Sceaux		Noisy-le-Grand	Argenteuil
	Sèvres		Noisy-le-Sec	Bezons
	Suresnes		Les Pavillons-sous-Bois	
	Vanves		Le Raincy	
	Ville-d'Avray		Rosny-sous-Bois	
	Bry-sur-Marne		Sevran	
	Cachan		Tremblay-en-France	
	Charenton-le-Pont		Villemomble	
	Fontenay-sous-Bois		Villepinte	
	L'Haÿ-les-Roses		Alfortville	
	Joinville-le-Pont		Arcueil	
	Nogent-sur-Marne		Boissy-Saint-Léger	
	Le Perreux-sur-Marne		Champigny-sur-Marne	
	Le Plessis-Tréville		Chennevières-sur-Marne	
	Saint-Mandé		Chevilly-Larue	
	Saint-Maur-des-Fossés		Choisy-le-Roi	
	Saint-Maurice		Créteil	
	Thiais		Fresnes	
	Vincennes		Gentilly	
			Ivry-sur-Seine	
			Le Kremlin-Bicêtre	
			Limeil-Brévannes	
			Maisons-Alfort	
			Sucy-en-Brie	
			Villejuif	
			Villiers-sur-Marne	
			Vitry-sur-Seine	

### Group 1

Group of densely populated communes, composed of central Parisian districts and one western commune adjacent to Paris (Neuilly-sur-Seine). The urban fabric and the built heritage are mainly composed of Haussmann-style buildings. Average housing prices in these communes are the highest

ones among the five groups. The average annual income is the highest among the five groups, and is well above the national average.

#### Group 2

Group of suburban communes, located mainly in the middle and south part of Hauts-de-Seine and the north of Val-de-Marne. These communes have a high value-added economic structure. Housing in this group is the most expensive after housing in Paris proper (groups 1 and 3). The incomes in these communes are the second highest incomes compared to other groups.

#### Group 3

Group of densely populated communes, it has the most important stock of housing as well as the highest population size among the five groups. It is composed by peripheral Parisian districts. Popular or formerly popular Parisian districts, the urban fabric is made up of former industries, mostly converted to housing. These districts are undergoing the phenomenon of gentrification. Average housing prices in this group are the second highest. The average annual income is third ranked among the five groups.

#### Group 4

Group of suburban communes mainly located in the eastern suburbs (eastern area of Seine-Saint-Denis and south of Val-de-Marne) with some exceptions from the department Hauts-de-Seine. The communes of this fourth group are the less populated ones and their stock of housing is the second less important. Their pavilion urban fabric is thus not dense but it is very urbanized. The socio-economic composition of the inhabitants is very heterogeneous. However, in average this group have the second lowest income compared to other groups.

#### Group 5

The last group is composed mainly of communes located in Seine-Saint-Denis. They are very industrial communes and concentrate the majority of the industrial equipment of Ile-de-France. Housing in this group is the most affordable compared to other groups. The urban fabric is dominated by individual housing. Average earnings in this group are the lowest.

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